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UNIFORM DISCHARGE CHARACTERISTICS OF NON-THERMAL PLASMA FOR SUPERFICIAL DECONTAMINATION OF BREAD SLICES

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ABSTRACT

The characteristics of uniform discharge of non-thermal plasma are investigated on the indigenously developed plasma system. The plasma reactor consists of two closely spaced parallel-plated electrodes, driven by an electrical power to generate uniform cold plasma. It was observed that, when the voltage across the electrodes increased beyond breakdown voltage, uniform discharge was observed. Distance between electrodes, applied voltage, thickness of dielectric barrier, carrier gas and surface finishing of electrodes are important characteristics for uniform plasma discharge which are studied and presented in this paper.

KEYWORDS: Non Thermal Plasma, Cold Plasma, Dielectric Barrier, Uniform Discharge

INTRODUCTION

Plasma is a neutral ionized gas generated using an electric discharge and it contains photos, electrons, ions, atoms, free radicals and excited or unexcited molecules (Hyun Jung Lee et al, 2012). Plasma kills various microorganisms due to these spices (Moreau et al, 2008). Recently Non thermal plasma has been added to the existing list of non-thermal processes for the decontamination of fresh produce and foods. There are a lot of sterilization methods to eliminate these microorganisms. Some of these methods rely on lethal heat treatment such as steam pasteurization, autoclaving, ohmic heating, etc. Thermal technologies have side-effects on nutritional, sensory and functional properties of treated foods, so alternative non thermal pasteurization methods such as high hydrostatic pressure, pulsed electric field, oscillating magnetic field, ionizing irradiation and high power ultrasound have been developed and studied in recent years. These processes retain quality of foods better than conventional methods; however, they have their own drawbacks. They are costly and required specialized equipment and trained personnel. Moreover, consumer acceptance and safety issues should be considered (Yun, H et al, 2010).

Non thermal plasma is a new discipline in food processing and in which the applied electrical energies dissociate the gaseous molecules into collection of ions, electrons, neutral gas molecules and other species (Nehra et al, 2008). Depending on the type of energy supply and amount of energy transferred to the plasma, density and temperature of the electrons are changed. These lead Plasma to be distinguished into two groups, high temperature plasma and low temperature plasma. In generation of cold plasma most of the coupled electrical energy is channeled to electron component instead of heating entire gas stream so the temperature of heavy particle remains near the room temperature, these characteristics make it suitable to be used in processes which high temperature is not desirable.

During plasma treatment, killing microorganisms on the food products are result of direct contact to antimicrobial active spices. Oxidation of the lipids, amino acids and nucleic acids with reactive oxygen and nitrogen spices cause changes that lead to microbial death or injury. In addition to reactive spices, UV photons can modify DNA of microorganisms and as a result disturb cell replication. (Laroussi et al, 2004, Mendis et al, 2000 & Moisan, M et al, 2002). Contribution of mentioned mechanisms depends on plasma characteristics and to the type of microorganisms. Characteristics of plasma includes voltage, working gas, thickness of dielectric barrier, distance of the microorganism from the discharge, etc are discussed in this paper.

Experimental Investigation

Experiment Conditions

The plasma system presented has been design and developed indigenously at Indian Institute of Crop Processing Technology consists of two planar electrodes, made of metallic plates and separated by variable gas or air gap (Figure 1). The electrodes are covered with Teflon sheets and energized by a high voltage power with a voltage range of 1-40kV and frequency of 50Hz. One of the electrode is covered with dielectric barrier (glass 1 to 3 mm thick), in order to avoid arc between the electrodes. The power supply (Figure 2b) specifications of the chamber are presented in table 1 and the transformer is provided with primary voltage variac to control the input voltage.

Figure 1: Metallic Electrodes with Teflon Sheet Covering

Table 1

Electrical Input	Primary	Secondary
Voltage	220-240V	40kV
Electrical Signal	AC (50Hz)	AC
Max electric Current	2.3 – 2.5 A	50mA

Plasma Reactor

A stainless steel vessel with size of 350x350x350mm and this reactor (Figure 2a) allows working pressure in the range of near atm to vacuum (Under 1 mbar). The distance gap between the two electrodes is mechanically adjudged and reactor is also provided with view glass to see the discharge.

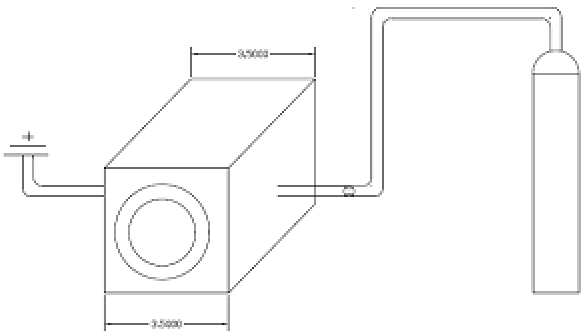

Figure 2a: Plasma Reactor Configuration

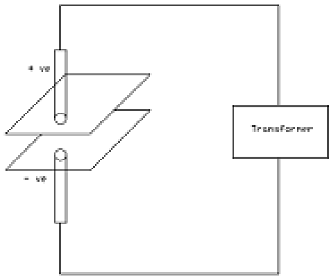

Figure 2b: Power Supply to Electrodes

RESULTS AND DISCUSSIONS

It was resulted from the experiment that for small values of the applied voltage there is no filamentary discharge can be seen between the two electrodes and is due to the fact that the gas molecules did not gain enough energy to get first and secondary ionization. However, when the voltage across the electrodes increased beyond breakdown voltage, filamentary discharge was observed (Figure 3a) and when enough energy is applied, uniform and homogeneous discharge was produced throughout the electrode gap. Uniform discharge was visually appeared once the breakdown voltage between the electrodes is attained and light emission from the plasma is observed. At the beginning, the plasma covers small area of electrode and moves around. It quickly spreads to cover entire electrode, when input power is increased. Visually the discharge appears uniform throughout the volume and has purplish-white glow without any arcing.

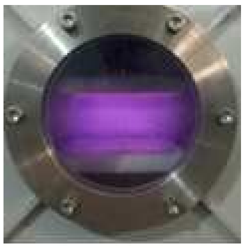

Figure 3a: Sharp Arcing from Electrode and Discharge **Figure 3b: Uniform Plasma Discharge**

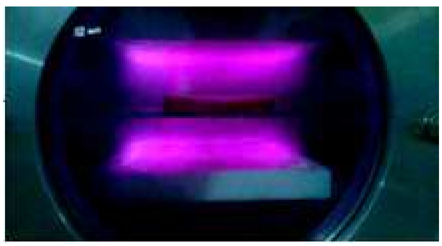

Figure 4: Bread Slice Sample between Uniform Plasma Discharges

Figure 3a shows that when the distance between the electrodes are not uniform throughout the electrode surface, it produced sharp arc and which will not lead to uniform discharge. It was found that sharp filamentary arc may also develop due to the presence of impurities on the electrode surface. Uniform plasma discharge was generated in the developed system when applied voltage is higher than the breakdown voltage, impurity free electrode surface and uniform distance between electrodes. It was also found that when the food samples like bread slices are exposed (Figure 4) under uniform

discharge of non-thermal plasma, surface microbes are completely decontaminated.

CONCLUSIONS

It was concluded through the experiment that relatively homogeneous and non-thermal uniform glow discharge plasma could be generated between parallel plates in the indigenously developed plasma system in the presence of air using high voltage power supply operating at 50Hz frequency. Non thermal plasma is an emerging technology for reducing surface decontamination on the bread slices and similar food products. This technology is increasingly finding acceptance among food processing industries for surface decontamination. Further the effect of non-thermal uniform glow discharge plasma on sensitive constituents of foods have to addressed for finding wider application within food industries.

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